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月球着陆器软着陆状态跳跃半主动控制

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State jump Semi active Control of Lunar Lander Soft Landing

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摘要 将磁流变阻尼器应用到月球着陆器着陆机构中，进行减震与缓冲。考虑到着陆初始姿态角的不定和月面斜角的未知，建立起着陆器软着陆动力学模型。基于磁流变液在高速流与长冲程时的阻尼特性，分析了磁流变阻尼器的力学特性。应用安全角面的概念定义安全着陆所要求的着陆初始姿态角与月面斜角之间的关系，建立状态跳跃控制策略，实现软着陆半主动控制。通过与某型被动控制的着陆器进行对比分析，研究了半主动控制。研究结果表明：当允许的最大加速度响应不超过8g时，磁流变半主动状态跳跃控制的安全角面为理想安全角面的0.977 4，是被动控制安全角面的4.2倍,最大加速度变化的相对标准差为被动控制的0.59；而且当着陆初始姿态角以及月面斜角很大时，月球着陆器姿态角变化少，保证月球着陆器平稳着陆。

关键词： 半主动控制 磁流变阻尼器 状态跳跃 软着陆 月球着陆

Abstract： Magnetorheological (MR) damper is applied to lunar landing system for shock absorption and vibration reduction. In consideration of the uncertain initial landing attitude angle of lunar lander and the unknown slope of lunar surface, a soft landing dynamic model is built. The mechanical property of MR damper is analyzed in view of the damping characteristics of MR fluid with high speed and long stroke. The concept of safe angle scope is used to define the relationship between initial landing attitude angle and lunar slope, and a state jump algorithm is developed to realize semi active control during soft landing. Compared with a certain type of passive lunar lander, the semi active control is analyzed. Numerical results show that the safe angle scope of semi active state jump control for MR is 0.977 4 times that of the perfect one, and 4.2 times that of the passive one when the allowable peak acceleration response does not exceed 8g. It is found that the relative standard deviation of the maximal acceleration variation is 0.59 times that of the passive one. Furthermore, when the initial landing attitude angle and lunar slope are very large, the attitude angle of lunar lander changes little, which ensures a smooth landing of the lunar lander.

Keywords： semi active control MR damper state jump soft landing lunar landing

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